Lasers in Surgery and Medicine 26:105–107 (2000)

In This Issue

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Dermatologic laser surgery is regarded as one of the fastest growing areas in the emerging fields of photomedicine and biomedical optics. Lasers are now the treatment of choice for several clinical entities for which no reliable or effective modality was previously available. Attend almost any academic dermatology or plastic surgery conference and you are likely to find many lectures that relate to dermatologic laser surgery. This special issue of *Lasers in Surgery and Medicine* focuses on those areas of dermatologic laser surgery having the greatest concentrations of research effort and clinical potential.

The evolution of the laser as a medical device for dermatologic surgery has been a process of continued improvement. As with any such device, the most efficacious and appropriate use requires an understanding of the mechanisms of light interaction with tissue as well as the properties of the laser itself. Research into an improved understanding of the optical and thermal characteristics of human skin has made it possible to concentrate not on the effects of any particular laser system, but on basic photo-biological and -physical principles of laser tissue interaction. The lasers available in the 1960s, 1970s, 1980s, and early 1990s offered few possibilities for modification. However, modern technology allows us to manipulate the physical characteristics of lasers and design them for specific therapeutic purposes.

The laser has many inherent physical properties that contribute to its ability to effect a specific biological outcome in human skin. Most important, from a clinical point of view, are the properties of emitted wavelength and pulse duration. If the clinical objective is to cause selective destruction of a specific chromophore, the wavelength chosen should match the high absorption of the targeted molecule relative to other optically absorbing molecules. Additionally, the laser pulse should be suitably brief so that all of its energy is uniformly invested in the target chromophore before much heat is lost by thermal diffusion. If these properties are optimized, then a maximum transient temperature differential between the target and adjacent structures is achieved with high spatial selectivity. Anderson and Parrish first identified this concept, termed selective photothermolysis, in 1983 [1]. As such, it represents an important advance in photomedicine which has greatly enhanced laser use in dermatologic surgery. The contribution by Alora and Anderson demonstrates how the concept of selective photothermolysis has been applied to the clinical management of patients with hypervascular skin lesions, pigmented lesions, tattoos and unwanted human hair [2].

Although selective photothermolysis has significantly improved the therapeutic outcome for many patients in response to laser treatment, the success rate can be very low for some types of hypervascular skin lesions if the ultimate standard required is complete blanching of the lesion. Choice of wavelength also determines the depth to which light penetrates with sufficient energy to effect tissue change. Longer wavelengths of light, within the visible spectrum, which penetrate further into human skin are more suitable for deeper lesions. For larger blood vessels recalcitrant to laser therapy, longer pulse durations, which will produce higher intravascular temperatures over longer periods of time, are needed. A wide variety of optical light sources have recently been developed that incorporate longer wavelengths and pulse durations to treat hypervascular skin lesions and these are discussed in the paper by Dover and Arndt [3].

For many lesions amenable to laser therapy, epidermal melanin represents an "optical barrier" through which light must pass to reach the targeted dermal chromophore. Melanin absorption causes localized heating of the epidermis, which may, if not controlled, produce permanent complications such as scarring or dyspigmentation. Unfortunately, for many lesions the threshold for epidermal damage following laser therapy is

lower than that for target chromophore destruction. Moreover, absorption of laser energy by epidermal melanin reduces the light dosage reaching the target, thereby decreasing the amount of heat produced in the target and leading to suboptimal heating of the lesion. In an attempt to address the aforementioned problems, several approaches to skin cooling have been utilized to protect the epidermis during laser exposure by increasing the threshold for epidermal damage as discussed in the manuscripts by Pfefer et al. and Zenzie et al. [4,5].

Several lasers and non-coherent light sources have been developed for the treatment of unwanted human hair. Permanent hair removal is difficult to achieve for a number of reasons. Most systems target melanin within the entire follicle, which requires the use of long pulse durations (on the order of milliseconds), and high energy densities for successful photocoagulation. Hair follicles are capable of regeneration although the pleuripotential cell source remains unknown; the bulge and dermal papilla are considered the most likely candidates. The size and melanin content of follicles vary with anatomic location making them more difficult to target. The majority of patients receiving laser therapy for the removal of unwanted human hair achieve a significant delay (generally 3–9 months) in hair re-growth. Advantageously, laser treatment is generally faster and less painful than shaving, tweezing, waxing, or chemical/surgical depilation and the incidence of adverse effects is low. The study by Campos et al. investigates the long-term efficacy and safety of a ruby laser system, that incorporates a pulse duration of 3 ms, designed for hair removal [6]. Another factor influencing the outcome of laser treatment of unwanted human hair is the follicular growth cycle (anagen, catagen, or telogen). Efficacy evaluations require observation for at least one complete hair cycle, a minimum of 6–8 months. Kolinko and Littler have developed a mathematical model to reliably predict results for various hair removal laser systems and other techniques [7].

Laser skin resurfacing (LSR) for the treatment of rhytides, photodamaged skin and acne scars has received much attention from the media, patients and physicians alike. LSR can achieve excellent results but success is dependent on a variety of factors. The best results are obtained when the attending physician understands the interaction of laser light with human skin, chooses carefully candidates for surgery, uses effective pre- and post-operative regimens and is prepared to handle potential complications. The carbon dioxide laser was the first system used for laser skin resurfacing that achieved worldwide attention. More recently, the erbium:yttrium aluminum garnet (Er:YAG) laser has been developed for the same clinical indications. This laser emits light at a wavelength of 2940 nm, which is absorbed by tissue water sixteen times more efficiently than the carbon dioxide laser wavelength thus enabling more superficial and controllable ablation with minimal nonspecific thermal damage to adjacent skin structures. Zachary [8] and Newman et al. [9] describe their favorable experiences with cosmetic Er:YAG LSR. Repetitive Er:YAG laser exposure can produce results similar to those seen after carbon dioxide LSR. Majaron et al. demonstrate how coagulation of dermal collagen deeper than 200 μm below the epidermal-dermal junction can be induced by repetitive Er:YAG laser irradiation [10].

Despite widespread prophylactic use of antibiotics and antivirals, pre- and post-operatively with LSR, wound infections appearing within 2–10 days after surgery remain a worrisome complication. Recently, there has been an increased incidence and awareness of *Candida* infections after LSR in patients who received appropriate antibiotic and antiviral prophylaxis. As reported by Conn and Nanda, addition of the antifungal fluconazole to the post-operative regime between days 3–8 significantly promoted wound re-epithelialization in patients undergoing full-face LSR [11].

Both carbon dioxide and Er:YAG LSR completely disrupt or remove the epidermis. The resulting open wounds require daily care to optimize healing and contribute to significant patient cosmetic morbidity. The concept of nonablative laser treatment of rhytides by stimulating dermal collagen formation, without epidermal injury, was first described in 1997 [12] and since then several systems using this approach have been tested in human subjects. Although minor improvements in rhytides were achieved in the studies reported herein by Ross et al. [13] and Goldberg and Cutler [14], optimization of treatment parameters may further improve these results and provide a much more effective and, most importantly safer approach than ablative LSR.

The conclusive diagnosis of diseases such as skin cancers still depends on excisional biopsy followed by histochemical staining and pathological interpretation. Selecting biopsy sites on the skin

is inevitably prone to sampling errors and necessarily accompanied by delay in diagnosis and expense. With the goal of guiding or even replacing excisional biopsy, numerous imaging techniques are in development as a means of "optical biopsy" to provide immediate, localized and diagnostic information to the attending physician. Polarized light can be used to obtain images of superficial tissue structures such as human skin and Jacques et al. present a study of the transition of linearly polarized light into randomly polarized light during propagation through biological tissues of potential diagnostic use [15].

I am indebted to the contributing authors for the exercise of their time, talents and experience in preparing manuscripts for inclusion in this special issue of *Lasers in Surgery and Medicine* to foster the educational process. It is our collective hope that their papers will stimulate further discussion and experimentation in the fields of photomedicine and biomedical optics in general and dermatologic laser surgery in particular.

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